Please check the examination details below before entering your candidate information

| Candidate surname | Other names |
|---|---|
| | |

Centre Number

Learner Registration Number

**Pearson BTEC Level 3 Nationals Diploma, Extended Diploma**

**Time** 50 minutes

**Paper reference** **31627H/1P**

# Applied Science

## UNIT 5: Principles and Applications of Science II

### Physics

### SECTION C: THERMAL PHYSICS, MATERIALS AND FLUIDS

**You must have:**
A calculator, a ruler and a pencil.

Total Marks

## Instructions

- Use **black** ink or ball-point pen.
- **Fill in the boxes** at the top of this page with your name, centre number and learner registration number.
- Answer **all** questions.
- Answer the questions in the spaces provided
  – *there may be more space than you need.*

## Information

- The exam comprises three papers worth 40 marks each:
  – Section A: Organs and systems (Biology)
  – Section B: Properties and uses of substances (Chemistry)
  – Section C: Thermal physics, materials and fluids (Physics).
- The total mark for this exam is 120.
- The marks for **each** question are shown in brackets
  – *use this as a guide as to how much time to spend on each question.*
- The formulae sheet can be found at the back of this paper.

## Advice

- Read each question carefully before you start to answer it.
- Try to answer every question.
- Check your answers if you have time at the end.

*Turn over* ▶

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**Answer ALL questions. Write your answers in the spaces provided.**

**Some questions must be answered with a cross in a box ☒. If you change your mind about an answer, put a line through the box ☒ and then mark your new answer with a cross ☒.**

**1** (a) Which statement correctly describes the internal energy of a system?

**(1)**

☒ **A** The kinetic energy of the molecules only.

☒ **B** The potential energy of the molecules only.

☒ **C** The sum of the potential energy and kinetic energy of the molecules.

☒ **D** The difference between the potential energy and the kinetic energy of the molecules.

(b) Complete Sentence 1 to define the second law of thermodynamics.

**(1)**

When an energy transfer takes place in a system, the ..... of the system increases.

**Sentence 1**

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(c) (i) Figure 1 shows a cylinder, some trapped air and a moveable piston.

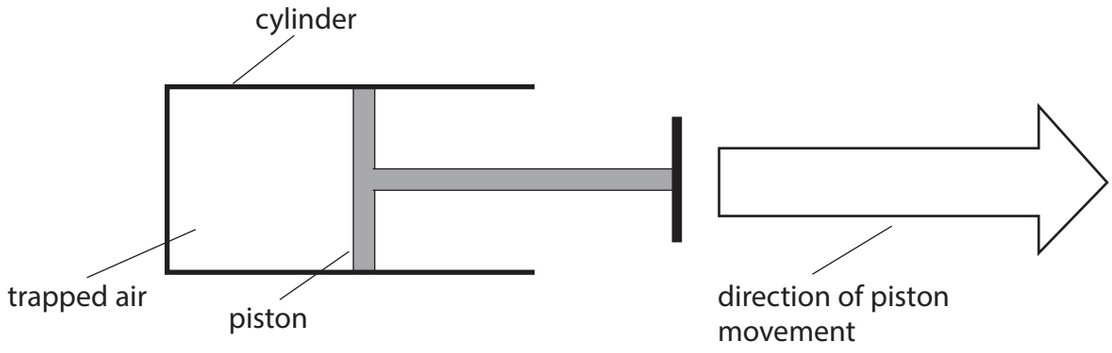


**Figure 1**

Explain why the pressure changes when the piston moves slowly to the right.

Your answer should refer to molecules in the trapped air.

**(2)**

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(ii) A sealed box contains 8.0 moles of a gas.

The volume of the gas in the box is 0.15 $m^3$.

The pressure of the gas in the box is 150 000 Pa.

Calculate the temperature of the gas in the box.

**(3)**

$R = 8.31\ J\ mol^{-1}\ K^{-1}$

Use the equation: $pV = nRT$

Show your working.

temperature of the gas = ..... K

**(Total for Question 1 = 7 marks)**

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**2** (a) Which physical property measures the resistance to flow in a fluid?

**(1)**

- ☒ **A** Density.
- ☒ **B** Pressure.
- ☒ **C** Temperature.
- ☒ **D** Viscosity.

(b) Draw lines between the dots shown in column X and column Y in Figure 2 to show a streamline air flow.

**(1)**

column X column Y

**Figure 2**

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(c) Figure 3a shows a car just before passing a lorry.

Figure 3b shows the car passing the lorry.

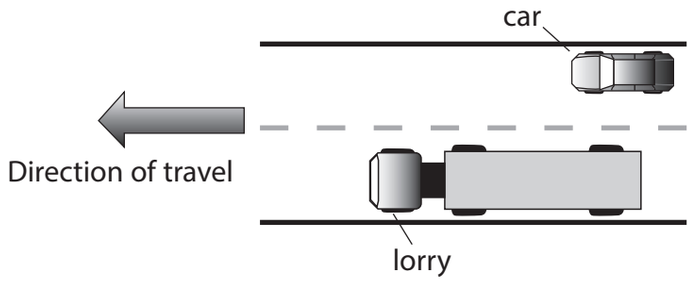


**Figure 3a**

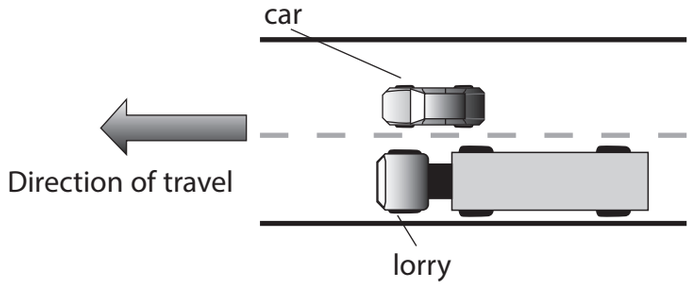


**Figure 3b**

As the car is passing the lorry, the air flow moves the car towards the lorry.

Explain why the air flow moves the car towards the lorry.

**(4)**

**(Total for Question 2 = 6 marks)**

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**3** A power station generates electrical energy.

A turbine in the power station is a heat engine.

(a) Describe what a heat engine does.

**(2)**

(b) Steam enters two identical turbines at the same temperature.

The temperature of the steam leaving turbine A is lower than the temperature of the steam leaving turbine B.

Explain the advantage of using turbine A rather than turbine B.

**(2)**

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(c) The power station has an efficiency of 0.45.

The output energy is $1.2 \times 10^9$ J.

Show that the input energy is approximately $2.0 \times 10^9$ J.

**(3)**

Use the equation: Efficiency = $1 - \frac{Q_{out}}{Q_{in}}$

Show your working.

input energy = ..... J

**(Total for Question 3 = 7 marks)**

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**4** (a) A learner observes that a puddle of water slowly disappears when heated by the Sun on a warm day.

(i) Name the process that makes the puddle disappear.

**(1)**

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(ii) Describe how the puddle disappears.

Your answer should refer to molecules of water.

**(2)**

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(b) (i) A pan of water is heated.

$2.00 \times 10^6$ J of energy is used to change some water into steam.

The water and steam are at the same temperature.

The specific latent heat of vaporisation of water is $2.26 \times 10^6$ J kg$^{-1}$.

Calculate the mass of water changed to steam.

**(3)**

Show your working.

mass of water changed to steam ..... kg

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(ii) Explain why the temperature of the water stays at 100 °C when changing from water into steam.

**(2)**

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**(Total for Question 4 = 8 marks)**

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**5** (a) Identify the correct unit of Young's modulus.

**(1)**

- ☒ **A** $kg\,m^{-3}$
- ☒ **B** $N\,m^{-2}$
- ☒ **C** $N\,m$
- ☒ **D** $Pa\,m^{2}$

(b) Which property allows steel to be drawn into a wire?

**(1)**

- ☒ **A** Brittleness.
- ☒ **B** Ductility.
- ☒ **C** Malleability.
- ☒ **D** Strength.

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(c) A learner applies a force to stretch a steel spring.

The stretch, $\Delta x$, of the spring is 65 cm.

The work done, W, in stretching the spring is 5.0 J.

Calculate the stiffness constant, k, for the spring.

**(4)**

Assume that the spring is not extended beyond its elastic limit.

Use the equation: $W = \frac{1}{2} k(\Delta x)^2$

Show your working.

stiffness constant, k = ..... $N\,m^{-1}$

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(d) A steel wire and a strip of polythene bag are stretched by adding weights to each.

Figure 4 is the stress-strain graph for the steel wire and the polythene bag when weights are added and removed.

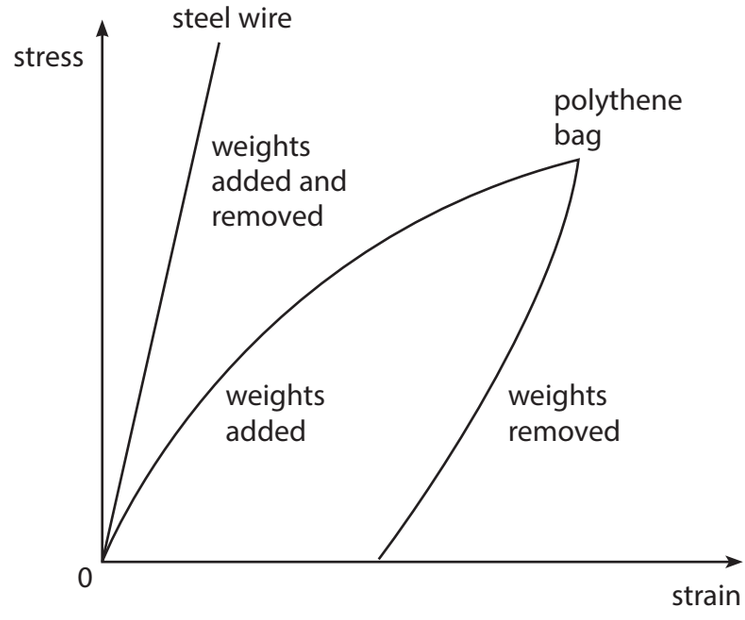


**Figure 4**

Compare the similarities and differences of the elastic and plastic properties of the **two** materials.

**(6)**

You can use and annotate Figure 4 to support your answer.

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**(Total for Question 5 = 12 marks)**

**TOTAL FOR SECTION C = 40 MARKS**
**TOTAL FOR EXAM = 120 MARKS**

## Formulae Sheet

### Mechanics

| | |
|---|---|
| Work | $W = F\Delta x$ |
| Work done by a gas | $W = p\Delta V$ |
| Efficiency | $\text{efficiency} = \dfrac{\text{useful energy output}}{\text{total energy input}}$ |
| Efficiency for heat engines | $\text{efficiency} = 1 - \dfrac{Q_{out}}{Q_{in}}$ |
| Maximum theoretical efficiency | $\text{efficiency} = 1 - \dfrac{T_c}{T_H}$ |

### Thermodynamics

| | |
|---|---|
| Ideal gas equation | $pV = NkT$ |
| First law of thermodynamics | $Q = \Delta U + W$ |
| Specific heat capacity | $Q = mc\Delta T$ |
| Specific latent heat | $Q = mL$ |

### Materials

| | |
|---|---|
| Density | $\rho = \dfrac{m}{V}$ |
| Young's modulus | $E = \dfrac{\text{stress}}{\text{strain}}$ OR $E = \dfrac{FL}{A\Delta x}$ |
| | $\text{stress} = \dfrac{F}{A}$ |
| | $\text{strain} = \dfrac{\Delta x}{L}$ |
| Hooke's law | $F = k\Delta x$ |
| Work done in stretching / compressing a wire / spring | $W = \dfrac{1}{2} F\Delta x$ |
| | $W = \dfrac{1}{2} k(\Delta x)^2$ |

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